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Identification of spatial agglomerations in the German food processing industry

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Identification of spatial agglomerations in the German food processing industry

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Abstract— This paper deals with the identification of spatial agglomerations in the German food processing industry, using the Cluster Index developed by Sternberg and Litzenger. Previous studies have analyzed this industry as one of several others utilizing highly aggregated data. The results of these studies mostly indicate a lack of agglomerations for the German food industry. Given the very heterogeneous character of this branch, an analysis at such an aggregated level might provide flawed results. Therefore, the following study analyzes German industry sectors for the first time at a highly disaggregated spatial (429 districts) and sectoral (23 subsectors of food processing industry) level. Results show that spatial agglomerations exist for several subsectors. This holds especially for processing and preserving of meat, fish, fruit, wine and milk processing as well as for breweries and the processing of mineral water.

Keywords— Regional Cluster, Spatial Economics, German Food Processing Industry

I. INTRODUCTION

During the last few decades, regional clusters have attracted increasing attention in spatial economics as well as in politics. The popularity of the topic is demonstrated by a growing number of publications worldwide (for recent reviews of the literature see [1], [2]) as well as by regional political initiatives [3]. The increasing interest in this concept is principally based on insights that local factors, such as knowledge creation, face-to-face contacts or trust-based relationships are important to enhance regional as well as firm performance.

Several studies have analyzed whether agglomeration exists in the German industry, using qualitative as well as quantitative methods (e.g. [4], [5], [6], [7]). Results for the food processing industry as well as for different subsectors mostly show a dispersed geographical distribution of enterprises without any cluster activities. However, those studies

are based on highly aggregated data. For the sector of food processing, analyses were realized for the whole industry and for the nine different sectors (e.g. “manufacture of beverages”, “processing and preserving of meat products”).¹ Due to the heterogeneity of the German food processing industry, with about 535,000 employees working in 33 different subsectors [8], an analysis at such an aggregated level is not adequate [9].² Therefore, this study, as similar ones dealing with cluster analysis in the food processing industry in other parts of the world, is based on more disaggregated data (e.g. [11]). Thus, the paper aims to assess whether spatial agglomerations exist at the level of different subsectors of the German food processing industry (four-digit level of the WZ03).

The paper is structured as follows: First, to provide the general theoretical background, the concept of clusters within spatial agglomeration theory is briefly discussed in the next section. In the second part of the paper, different methods to identify clusters are presented by focusing especially on the Cluster Index (CI), which will be used in the empirical analysis of this paper. This is followed by a description of the data used (section IV). The results of the analysis are presented and discussed in the fifth part. Finally, the findings are elaborated upon and conclusions are drawn.

II. SPATIAL AGGLOMERATION THEORIES

Theories on spatial agglomerations have gained increasing attention within economic geography in recent decades. They all trace back to Marshall’s early work on industrial districts [12]. He focuses on a triad of agglomeration economies: the availability of skilled

¹ That is, the two- or three-digit level of the German Classification of Economic Activities, Version 2003 (WZ 2003).

² Several case studies on spatial agglomerations in the food processing industry are also realized at a more disaggregated level (e.g. [10]).

labour, the growth of subsidiary trades in the vicinity and possible technological spill-over effects due to an increased flow of information and knowledge.

In the 1990s especially, several streams of spatial theories evolved. Beside the concept of learning regions (e.g. [13]) and the innovative milieu (e.g. [14]), the cluster approach became largely popular. While the former theories mainly concentrate on innovative activities and are therefore often applied in studies about high-tech industries, the concept of clusters in a multidimensional way analyzes relationships along the supply chain, strongly focussing on competitiveness [15]. Due to its relevance in regional sciences as well as in regional politics it will also be used in the following analysis.

Although the term ‘cluster’ was first mentioned in Lausén’s work (1973) [16], later contributions on this concept mostly refer to Michal Porter as its originator. Within his theory of international competitiveness he developed the well known ‘diamond model’ in which the competitive advantage of industries within a nation is determined through four key factors: the proximity to related and supporting industries, competitors, a sophisticated demand and research institutions ([17], [18]).³ At the beginning of his work, he mainly focuses on industrial phenomena. That is, competitive ‘sectoral clusters’ within a nation are determined by strong vertical and horizontal relationships. Later on, territorial dimensions receive greater attention in an analysis of ‘regional clusters’. In addition to the sectoral element he underlines the importance of geographical and network phenomena [20].⁴

Due to the popularity gained by the concept of regional clusters in the following decades, the number of publications as well as the variety of definitions increased greatly (for an overview see [19], [23]). Gordon and McCann [24] state that one reason for the multi-perspective view of clusters is the adoption of this concept by several scientific disciplines. Each of these approaches focuses on different aspects. Due to the large number of definitions and a lack of drawing

clear boundaries (geographical as well as sectoral), the concept has often been described as ‘chaotic’ [19].

We will base our understanding of clusters on Porter’s view, however taking into consideration the main problems of his conception. As a result, clusters are defined as “geographic concentrations of interconnected companies and institutions in a particular field” [18]. Following this definition, clusters are based on vertically (buyer/supplier) and horizontally (use of common technologies, customers etc.) linked enterprises which can be related through cooperation as well as through competition. Another important factor in this definition – which has not been that relevant in the industrial district concept – is the relationship between firms and associated institutions such as universities, consultancies, associations or other R&D-institutes ([11], [18]). These structures within spatial agglomerations strengthen regional as well as firm competitiveness.

Although a wide range of cluster definitions exists, it is common sense that the different actors within these agglomerations have to be interconnected (e.g. [11], [18], [25]). What remains still unclear is the dimension of the relations ([19], [26]). While some authors focus solely on exchange relationships [24], others highlight the importance of additionally being socially embedded in the cluster (e.g. [11], [27]). In our view, social relationships of actors are considered as a crucial element of clusters.

A problem of clarity according to Porter’s definition is based on the emergence of cluster structures. Several authors state that clusters have to arise through a self-enforcing process ([5], [6]). Thus, clusters close to natural resources or sophisticated clients are mostly ignored although a direct relationship between these resources and the cluster emergence is not verified. In contrast, several studies about the wine industry in different countries provide evidence of typical cluster effects despite natural conditions ([11], [28], [29], [30], [31]). Due to the difficulty of measuring the self-enforcing process and the proven existence of regional clusters close to natural resources it is, in our view, highly important to include these industries as well.

Contrary to the results of several studies in economic geography, the hypothesis of this analysis is that regional concentrations in the German food

³ Porter uses the concept of competitiveness in a varied manner, depending greatly on his focus of analysis. The conceptual scale reaches from enterprises to industries, regional or sectoral clusters to the national level. His universal application of this complex concept has been strongly criticized (see e.g. [19]).

⁴ In literature, the distinction between ‘sectoral’ (or ‘industrial’) and ‘regional clusters’ is widely acknowledged (e.g. [21], [22]).

processing industry exist. However, due to the aforementioned diversity within this sector, we argue that clusters are relevant at the level of specific food branches. Thus, an analysis at a more disaggregated level seems necessary to detect clusters in this sector. That is why the following study will apply quantitative methods at a four-digit level.

III. METHODOLOGY

The problem of varying cluster definitions described holds as well for the measurement of this phenomenon (for an overview see [32], [33]). Concerning this aspect, Martin and Sunley [19] state that “there is no agreed method for identifying and mapping clusters, either in terms of the key variables that should be measured or the procedures by which the geographical boundaries of clusters should be determined.” Therefore, the number and size of identified clusters varies among different studies due to the chosen boundary and measurement methods ([34], [35]).

Generally, the methods to identify clusters can be differentiated into top-down (quantitative methods) and bottom-up (mostly qualitative case studies in a defined region) approaches (for a further explanation see [19], [32]). The analysis in this paper will focus on the former because our aim is to identify nationwide clusters which cannot be detected through the bottom-up approach.

When using the top-down method, the spatial concentration of an industry has to be analyzed in relation to the whole region. Most previous studies seeking to identify regional clusters were based on the spatial division of labour (for Germany e.g. [4], [6], [36]). However, without taking into account the dimension of the analyzed unit, industrial specialization instead of concentration is measured. To analyze the spatial division of labour, Sternberg and Litzenberger [5] create the relative industrial stock (IS) on the basis of the location quotient (LQ). It is calculated by the ratio of the share of employment of the analyzed sector to the inhabitants in the examined district in relation to the ratio of employment of the analyzed sector related to the inhabitants in the overall

region:⁵

$$IS_{ij} = \frac{e_{ij}}{b_i} \bigg/ \frac{\sum_{i=1}^n e_{ij}}{\sum_{i=1}^n b_i} \quad (1)$$

with:

e_{ij} number of employees in district i and sector j
 b_i number of inhabitants in district i

$\sum_{i=1}^n e_{ij}$ no. of employees of sector j in the whole region
 $\sum_{i=1}^n b_i$ number of inhabitants in the whole region

The IS can take values ranging from zero to infinity. It is equal to one if a district is totally identical to the situation of the overall region. Values below one indicate an underrepresented specialization (with zero demonstrating no activity of the contemplated sector), while numbers above one detect an overrepresentation of specialization.

But the dimension of the units – or in our case the districts – is highly important concerning our definition of clusters, which focuses on enterprises in close proximity to each other. Instead of using inhabitants or employment as a reference value, it should focus on the area. Otherwise it is theoretically not expected that the industry is spatially distributed equally [37]. By considering only the relative industrial stock it is possible that scarcely populated regions, in which most inhabitants work in the same branch, are considered as a cluster without being spatially concentrated related to the overall region. That is why Sternberg and Litzenberger [5] propose an extension of the IS with the relative industrial density (ID).

This is formally defined as follows:

$$ID_{ij} = \frac{e_{ij}}{a_i} \bigg/ \frac{\sum_{i=1}^n e_{ij}}{\sum_{i=1}^n a_i} \quad (2)$$

⁵ In comparison to the IS, the LQ utilizes total employment instead of the number of inhabitants as the reference value.

with:

e_{ij} number of employees in district i and sector j
 a_i size of the district i

$\sum_{i=1}^n e_{ij}$ no. of employees of sector j in the whole region

$\sum_{i=1}^n a_i$ size of the whole region

For adequate cluster identification, solely the use of the ID is also not appropriate because in a highly populated city with a relatively small area the index could easily exceed the average of the overall region, although the analyzed sector is not of special importance relative to other branches. To avoid an elevation of the IS or the ID caused by one large company, the authors extend these two relative measures by the relative plant size (PS) to create their CI.

The PS is formally defined as follows:

$$PS_{ij} = \frac{e_{ij}}{p_{ij}} \bigg/ \frac{\sum_{i=1}^n e_{ij}}{\sum_{i=1}^n p_{ij}} \quad (3)$$

with:

e_{ij} number of employees in district i and sector j
 p_{ij} number of plants in district i and sector j

$\sum_{i=1}^n e_{ij}$ no. of employees of sector j in the whole region

$\sum_{i=1}^n p_{ij}$ no. of plants of sector j in the whole region

The control for firm size gives a better approximation to what we have defined as a cluster than the simple use of the IS or ID although clusters consisting of solely large companies are possibly not detected [7].

For an appropriate identification of regional clusters, the IS, the ID and the reciprocal of the PS are connected multiplicatively to create the CI [5].

$$CI = IS_{ij} \cdot ID_{ij} \cdot 1/PS_{ij} \quad (4)$$

As described for the IS, the two other components of the CI and hence the whole index also have the potential range from zero to infinity. The higher the value of this index, the stronger the clustering of the respecting sector turns out to be. The fact that the components of the CI are connected through multiplication results in extreme values having a higher influence than for example in additive connections [38]. An underrepresentation of a component could possibly be compensated by higher positive values of the other two elements. Hence, even in cities with a high number of inhabitants (and therefore possibly a lower IS) a cluster can be detected due to a higher ID. In contrast, also in a very specialized and scarcely populated huge rural district, clusters will be identified through a very high IS although the ID can be below one [5]. However, if one of the three components is zero, the whole index is consequently equal to zero and shows no activity of the analyzed sector in the respective region [39]. Due to the strong relationship between plants and employees, either all three components are equal to zero (or for the PS not definable)⁶ or they have a positive value for this indicator.

Generally, clusters are special concentrations of industries relative to the overall region. Therefore, in each sector this phenomenon exists to a very limited degree. For this reason, the relevant clusters should be marked by a very high CI. It is reasonable to build just five categories for a better interpretation as well as for an optimal graphical demonstration. Problems of information loss will not be so high due to building just one category for the underrepresented CI and four for different stages of concentrations because of the special focus on the latter aspect. To speak about potential clusters all three cluster components have to be overrepresented or compensated by at least one other element of the index. To choose different categories this analysis distinguishes between the single, the double, the quadruple and the octuple value of each element. Due to the open boundary of the

⁶ If there is no establishment in a district, the PS is not defined. Due to interpretative reasons, the values of the CI are changed to zero, indicating that there is no economic activity and an underrepresented distribution in that region.

index, the last category is defined as greater than the octuple value (512) up to infinite (see Table 1):

Table 1 Calculation of cluster boundaries

Value Index	CI	Category
Single Value	$CI = 1^3 = 1$	$CI \leq 1$: Under-represented or equal distribution
Double Value	$CI = 2^3 = 8$	$1 < CI \leq 8$: Overrepresented, but no cluster
Quadruple Value	$CI = 4^3 = 64$	$8 < CI \leq 64$: Potential cluster
Octuple Value	$CI = 8^3 = 512$	$64 < CI \leq 512$: Relevant cluster
Open boundary (< 512)	$CI = \infty$	$512 < CI < \infty$: Very relevant cluster

Source: Calculation on the basis of [21].

For example, the CI of 8 is reached if all three elements of the index are double the level for the district as for the whole region. But this is in our case interpreted solely as an overrepresented distribution with cluster tendencies. The somewhat arbitrary threshold value in this study is given with a CI higher than 64 (greater than the quadruple value).

Even though the inclusion of the ID can be criticized due to a greater difficulty to detect clusters in bigger districts than in smaller ones, without this element there are problems of not identifying clusters in highly populated districts (e.g. cities). Additionally, the extension through the PS can possibly obscure clusters with mainly large enterprises. However, this problem has not been verified in empirical studies and the positive effects of eliminating clusters due to big companies are seen as having greater importance ([7], [34]). Another advantage is that one receives a value to interpret for each analyzed district. Therefore, a better comparability than with other measures, such as the Gini coefficient or the location quotient, is reached. It is possible to directly identify in which district the cluster activities are while the other measurements only indicate that a concentration in a certain sector exists. The solid availability of data for

the German food processing industry is another asset for this calculation method.

This index has mainly been criticized for the following aspects: First, functional relations between enterprises and industries cannot be identified ([7], [27]). In addition, the index values are generally higher at a more disaggregated level due to a smaller number of enterprises and employees ([21], [40], [41]). Therefore, it is difficult to compare different studies based on diverging circumstances. Generally, there is no exact threshold value for the definition of a cluster. This has to be decided individually in each cluster study that applies the CI (e.g. [7], [27], [34]).

Related to the problem of comparability between different aggregation levels is the fact that the several subsectors in the food processing industry also diverge significantly in size (e.g. 100 establishments in “processing and preserving of poultry meat” to more than 11.000 establishments in “production of meat products”) [42].⁷

However, the lack of indicating functional relations as well as problems due to differences in sectoral and geographical size cannot be solved through any of the quantitative approaches (e.g. [34], [40], [43]). With this in mind, the CI seems to be the most advantageous measure for the following analysis.

Finally, it is important to underline that due to the failure of identifying relationships between enterprises and branches, this method, like most of the quantitative analyses, can only be considered as an important first step to detect potential agglomerations [44].⁸ Given that geographical proximity of firms does not necessarily imply that firms cooperate [26] and intersectoral relations cannot be identified due to the use of the classification systems, further studies should be conducted [44].

⁷ The same problem of diverging sizes of sectors holds for the two- and three-digit levels [21].

⁸ Recently, Titze et al. (2010) combined the CI with an input-output analysis to identify horizontal and vertical relationships at the same time. However, due to the data required for the latter method, it is unconvertible for the following level of analysis [7].

IV. DATA

For the calculation of the CI, data of enterprises and their employees as well as data of the inhabitants and the size of the analyzed districts are required at a highly disaggregated level. Data on enterprises and employees for the German food processing industry is provided by the German Federal Employment Services [45].⁹ At a highly disaggregated industrial and regional level, it provides the number of enterprises employing at least one person and the total number of employees in general for the 429¹⁰ German districts (*Kreise*) on the basis of the four-digit level for the year 2008. These levels are based on the German Classification of Economic Activities, Version 2003 (WZ03)¹¹ of the Federal Statistical Office. It corresponds to the Statistical Classification of Economic Activities in the European Union (NACE) which is an EU directive for all member states and is closely related to the International Classification of Economic Activities of the United Nations (ISIC). Although most analyses have been realized on a three-digit level, not only food processing specialists have claimed that functional relations can be better detected through the four- or even the five-digit level ([43], [44]).

The four-digit level of the WZ03 comprises 33 divisions for the chapter “DA” food processing industry (e.g. “production of meat products”, “manufacture of wine” or “manufacture of beer”). For statistical reasons, all divisions that include more than one hundred establishments were analyzed (that is, 23 subsectors). If enterprises are related to several subsectors, they are attributed to the sector with their main activity, measured by the added value [46].

Apart from the industry data at the four-digit level, we also need numbers on inhabitants and district size to calculate the CI. This data is obtained from the German Federal Statistical Office [47].

V. RESULTS

The analysis is mainly based on 23 subsectors of food processing. Additionally, some overall categories were calculated to underline the results. Due to the criticism that smaller sectors cause higher values in most quantitative measurements (see section III), we checked for the results of all subsectors of food processing if branches with a small number of establishments or employees have generally a higher number of “relevant clusters” (CI > 64) by using count data analysis. Results of the regression show no significant correlation. For this reason we use the aforementioned method to compare the different sectors of food processing.

Table 2 presents the number of districts in each CI-category for the different (sub)sectors. Results indicate that clusters can be identified for nearly all subsectors of food processing at the four-digit level (see the white categories in the last two columns of Table 2). In most sectors there are less than twelve clusters identified (CI below the threshold value of 64).¹² Only “production of meat products” (DA 1513) and “manufacture of bread, fresh pastry and cakes” (DA 1581) remain with no relevant cluster. These two subsectors demonstrate a strong disperse distribution: Nearly every district contains at least one establishment and the strong majority of CI values lie little below or above one.

Comparing these findings with the respective overall categories (light grey fields) shows an overrepresented number of clusters at the four-digit level. At the three-digit level, clusters are identified only in the category of “production and preserving of fish” (DA 152) in several districts adjacent to the sea.¹³ In the following sections, several reasons for these different results are given.

⁹ The data was especially requested for the following analysis and is not freely available. Due to the possibility of having less than three enterprises in one district it would violate the restrictions of data protection by German law.

¹⁰ Due to the data provided, the analysis is based on 429 districts, although after the reform of districts in Saxony the number decreased to 413.

¹¹ Although there has been a revision of WZ03 in 2008 (WZ08), the data we use are still organized according to the older version.

¹² One of the subsectors in which more than twelve districts are defined as a cluster is “manufacture of wine” (DA 1593). This aspect is mainly determined through the thirteen defined regions for quality wine in Germany in which the identified 19 districts are located.

¹³ The results mainly correspond to those of previous studies at the two- or three-digit level for German industries where just the fish industry has been identified as clustered (e.g. [4], [5], [6]).

Table 2 Distribution of 429 districts on the different CI-categories for (sub)sectors of the German food processing industry

Subcategory (WZ03-Code)	CI = 0	0 < CI ≤ 1	1 < CI ≤ 8	8 < CI ≤ 64	64 < CI ≤ 512	512 < CI
Processing and preserving of meat (1511)	140	170	78	33	7	1
Processing and preserving of poultry meat (1512)	370	15	11	23	8	2
Production of meat products (1513)	3	195	210	21	0	0
Production, processing and preserving of meat and poultry meat products (151)	2	104	199	23	1	0
Processing and preserving of fish (1520)*	322	42	35	19	7	4
Processing and preserving of fish (152)	322	42	35	19	7	4
Manufacture of fruit and vegetable juice (1531)	250	58	25	36	3	0
Processing and preserving of fruit and vegetables n.e.c. (1532)	277	53	53	39	7	0
Operation of dairies and cheese making (1551)	216	101	66	36	10	0
Manufacture of ice cream (1552)	341	24	39	14	8	3
Manufacture of grain mill products (1561)	152	146	96	30	5	0
Manufacture of prepared feeds for farm animals (1571)	282	44	51	40	11	1
Manufacture of prepared pet foods (1572)	356	19	24	21	5	3
Manufacture of bread and <u>fresh</u> pastry goods and cakes (1581)	0	192	223	14	0	0
Manufacture of rusks, biscuits, <u>preserved</u> pastry goods and cakes (1582)	300	44	37	38	9	1
Manufacture of cocoa, chocolate and sugar confectionary (1584)	267	60	56	39	5	1
Manufacture of macaroni, noodles, couscous and similar farinaceous products (1585)	349	14	24	27	14	1
Processing of tea & coffee (1586)	359	16	22	19	11	2
Manufacture of condiments / seasonings (1587)	333	21	35	29	11	0
Manufacture of homogenized food preparations and dietetic food (1589)	269	70	47	31	11	1
Manufacture of other food products (158)	0	191	229	9	0	0
Manufacture of distilled potable alcoholic beverages (1591)	271	63	45	41	7	1
Production of ethyl alcohol from fermented materials (1592)	333	24	37	28	13	2
Manufacture of wines (1593)	358	22	16	14	13	6
Manufacture of beer (1596)	139	130	98	53	9	0
Manufacture of soft drinks; production of mineral waters and other bottled waters (1598)	231	78	76	37	7	0
Manufacture of beverages (159)	39	206	132	51	1	0

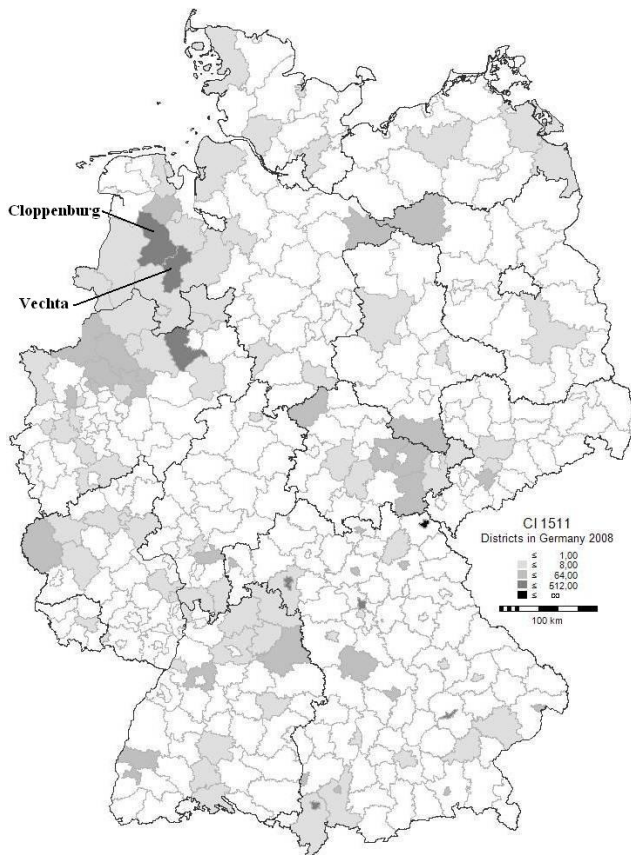
*The category “manufacture of fish” is the only one not being subdivided at the four-digit-level. Therefore, data are the same at both levels.

Source: Calculation on the basis of [44], [46].

A. Bias caused by differences in sector size

For the sample case of “processing and preserving of meat” (DA 1511), eight districts were identified as relevant clusters (see Figure 1).

Figure 1 Clusters in “processing and preserving of meat” (DA 1511)



These include Cloppenburg (CI = 237.45) and Vechta (CI = 107.95), both located in the federal state of Lower Saxony in northwestern Germany. The two adjacent districts demonstrated among the highest CI-values. According to the definition given in the theoretical part of this paper, these districts should be analyzed together in further studies due to the geographical proximity and possible common structures. Apart from Cloppenburg and Vechta, most of the districts in western Lower Saxony and in the north of the federal state of North Rhine-Westphalia

have a CI above one and are therefore overrepresented. This is another good indicator that these districts might be of higher importance for further analysis.

Along with these, another important district with a very high CI is the city district of Hof (CI = 813.2). Compared to Vechta, in Hof there are just half the number of establishments and employees, but the district is thirteen times smaller and has three times less inhabitants. Therefore, the CI increases to the amount mentioned and further studies have to analyze if this is due to coincidental location of enterprises in this sector or if “real” cluster structures exist.

Furthermore, in this sector there are 140 out of the 429 districts in which there is no establishment of the analyzed subsector located. An additional 170 districts have an underrepresented CI with at least one enterprise. Thus, three-quarter of all the districts have a CI which is below the German average of one (see white areas in Figure 1).

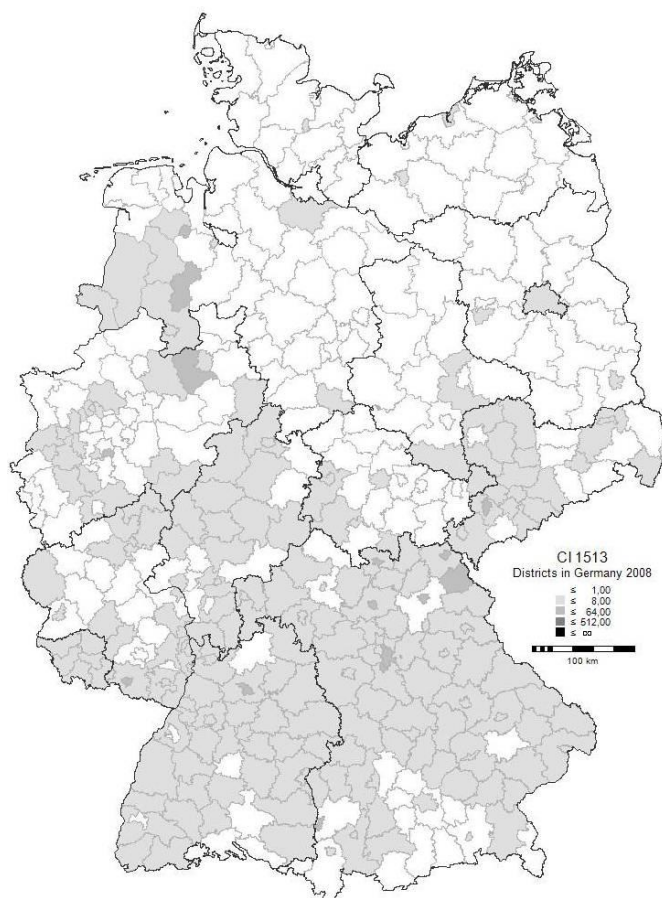
These results also hold for the closely related subsector “processing and preserving of poultry meat”, (DA 1512) although in this smaller branch the two previously mentioned districts are of different importance. In this case, Vechta with a CI of 5,734.94 has the highest value followed by the neighbouring district Cloppenburg (CI = 529.69). Taking these numbers for the subsectors of “processing and preserving of meat and poultry meat” together, it is evident that there is a very high cluster tendency for these branches in this region of northwestern Germany. Further analysis of the “manufacture of prepared animal feeds” (DA 1571) underlines these results. In this case, Vechta again has the strongest value (CI = 699.34), followed by Cloppenburg (CI = 129.5). The coincidence of higher values in these two districts is a good indicator for existing “related and supporting industries” as an element for a competitive cluster.¹⁴

However, the question remains as to how these results fit together with the lack of cluster tendencies in the main category “production, processing and preserving of meat and poultry meat products” (DA 151). Alongside the two “processing and preserving of meat” subsectors, the presented main category in the meat sector also includes the

¹⁴ See section II.

subcategory “production of meat products” (DA 1513), which contains a much higher number of establishments and employees (more than 93% of all plants) in relation to the other subbranches. In total, this sector has fourteen times more establishments and five times more employees than the other two sectors combined.

Figure 2 Clusters in “production of meat products” (DA 1513)



Due to the structure of primarily very small plants which are often situated near local demand, this is a highly dispersed sector (see Figure 2). For this reason no relevant cluster can be detected in our analysis. Additionally, there are just three districts which do not have a presence in the analyzed sector. This is very similar to what Litzenberger and Sternberg [5] found as well as the basis for the main critique in this paper. But considering the size of the sector “production of

meat products” in relation to the other two subsectors, it is evident that possible cluster structures in the latter cannot be detected due to the high amount of small and widely dispersed establishments of the former.

This distortion is one of the reasons why previous studies (e.g. [10], [11]) as well as cluster specialists use case studies at a sub-category level of food processing [9].

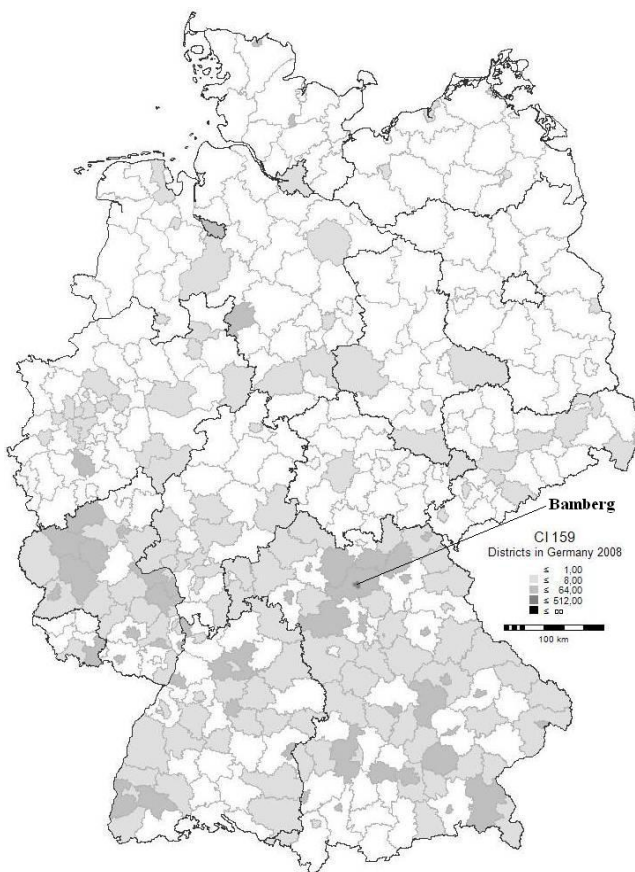
Beside the meat industry, there are other sectors where cluster structures also hold. This applies to fish, wine, milk and fruit processing as well as to breweries and the processing of mineral water. Several of these branches face other problems that limit their detection through quantitative studies at a highly aggregated sectoral level. This aspect will be discussed in the following section.

B. Bias caused by heterogeneous subcategories

While in the above presented case the subcategories can be characterized as very homogenous, one can find several other examples in which the overall levels contain a number of very heterogeneous subsectors. This holds especially true for the three-digit categories “manufacturing of other food products” (DA 158) and “manufacturing of beverages” (DA 159) which contain nine and eight subsectors, respectively. Nevertheless, these branches have often been analyzed at the three-digit level with the result of indicating an almost broad distribution (see [4], [5] and Table 2).

In the case of the manufacture of beverages there is just one district with a high CI (Bamberg = 197.97) (see Figure 3). Analyzing the data shows that 70% of the enterprises in this district are part of the beer manufacturing sector.

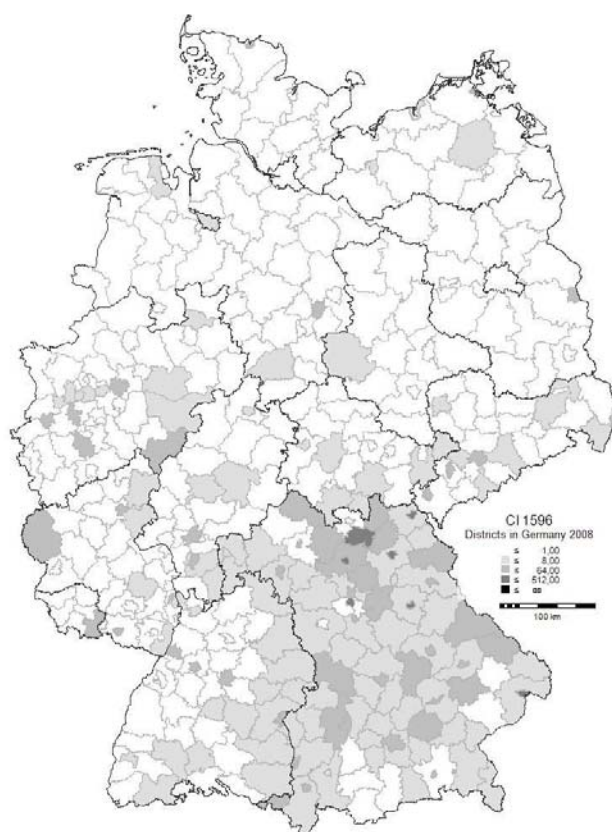
Figure 3 Clusters in “manufacture of beverages” (DA 159)



This aspect is highlighted by the fact that Bamberg even has a doubled CI if just analyzing the manufacture of beer (DA 1596). Similar results can be seen in districts with a high number of enterprises working in the manufacture of spirits (e.g. Cochem-Zell with a CI of 27.56). These findings as well as the results at the four-digit level, in which each subcategory of beverages contains more than seven clusters, highlight the necessity to analyze the data on a more disaggregated level.

As described in the theoretical part (see section II), several studies of the wine industry and therefore at the four-digit level have been realized in different parts of the world. Due to the thirteen defined regions for quality wine in Germany, an analysis of this industry might not be as interesting as, for example, in California, Chile, South Africa or Australia. For this reason we will focus our analysis on other important branches in Germany, such as the manufacture of beer. While in the main beverage category there was just one district with a highly relevant CI, in the subcategory of beer there are nine districts with a CI above 64, all of them located in the German federal state of Bavaria (see Figure 4). As described above, especially the city district of Bamberg (CI = 397.71) can be considered as strongly clustered in this branch. Additionally, the surrounding rural district of Bamberg (CI = 45.35) is also characterized by a high value and several adjacent areas, in addition, have relevant CIs: Bayreuth (CI = 148.98), Lichtenfels (CI = 87.99) and Kulmbach (CI = 48.72) in Upper Bavaria. Due to the close proximity of these districts, the whole region can be considered a very relevant cluster.

Figure 4 Clusters in “manufacture of beer” (DA 1596)



Apart from “manufacturing of beer”, cluster tendencies for subsectors of the category beverages can be found in the “manufacture of spirits” (DA 1591), the “manufacture of wine” (DA 1593) and the “manufacture of soft drinks and mineral water” (DA 1598). Latter, for instance, has very relevant cluster values in seven districts of Germany. The three districts Vulkaneifel (CI = 171.98), Ahrweiler (CI = 82.4) and Mayen-Koblenz (CI = 38.07)¹⁵ in the north of the German federal state of Rhineland-Palatinate are additionally in close proximity to each other. In further studies it is important to analyze if network effects and other cluster-inherent structures

¹⁵ Mayen-Koblenz is not one of the seven most relevant districts as it is related to the third category (“potential cluster”). In this relation, the district is solely mentioned due to the common borders with the other two districts.

are relevant for this region or if the elevated value is just caused by the natural resources of mineral springs without any of the previously defined cluster characteristics.¹⁶ As in most of the other subsectors of the food processing industry, natural resources play a crucial role for the choice of establishing a presence. But, for instance, Nestlé relocated its headquarters for bottled water to France due to the competitive environment [11]. Therefore, an analysis of the location attractiveness of regions for enterprises is especially important in the food processing industry, as in the exemplary case of mineral water.

The insights presented for the manufacture of beverages also hold for several other subsectors of the food processing industry, such as the “manufacture of other food products” (DA 158) in which the heterogeneity of subsectors (e.g. sweets and seasonings) is very problematic. In this case no relevant cluster can be detected for the overall category. Heilbronn has the highest CI in this section with 28.77, which is also caused by an elevated value in one subsector. However, results at the four-digit level only show a broadly dispersed distribution for one sector out of nine (“manufacturing of bread, fresh pastry and cakes” (DA 1581)). For the reasons shown in this section, a joint analysis of these industries is not justifiable either.

The results of the study prove that, due to the heterogeneity of the sector and bias caused by differences in subsector size, analyzing regional clusters in the food processing industry should be conducted at a highly disaggregated level. This paper provides a first look at the location of potential clusters in several subsectors of German food processing industry.

VI. CONCLUSIONS

This analysis demonstrates that some of the important elements to determine whether districts – in relation to an overall region – are concentrated or not are taken into account by the Cluster-Index. It is possible to detect potential clusters for regional political initiatives as well as already existing clusters

¹⁶ See section II.

in Germany. Another accomplishment of this method is the exact indication of the geographical districts in which the clusters of the analyzed sector are found, whereas other measurement methods only state if a certain sector is concentrated or not.

While several previous studies of the German manufacturing sectors realized their analyses at a highly aggregated sectoral level (two- or three-digit), this paper shows why the use of quantitative measurement methods for overall categories or for the whole food processing industry is inadequate. Two problems with using the CI at a highly aggregated level are presented: at first, cluster tendencies in different subsectors disappear due to larger subsectors in the same category, such as in the meat industry. Experts in the German meat sector can directly confirm cluster tendencies while Litzenberger and Sternberg [5], along with others, negate this fact in their studies. This controversy is caused by the dominating amount of establishments and employees in the subsector “production of meat products”. Even if the subsectors “processing and preserving of meat” and “processing and preserving of poultry meat” would be totally clustered, this tendency disappears in an aggregated quantitative analysis because these subsectors account for just 7% of all the establishments in the main category.

The second problem was illustrated by a comparison of some main categories with their different subsectors. While in the meat example the relationship between the different subsectors was very strong and size issues between the categories had to be addressed, in case of “manufacture of other food products” or “manufacture of beverages” the heterogeneity of most of the subsectors is underlined.

Contrary to the results of previous studies, the findings of this analysis show that clusters in the German food processing industry exist. These agglomerations have become identifiable by using quantitative measurement methods on a more disaggregated level. It is important to choose the right aggregation level in this branch because the structure of the food processing industry with more than thirty subsectors and about 535,000 employees is too complex and too heterogeneous to be analyzed as a “whole” in this regard.

This first analysis of potential agglomerations in the German food sector at such a disaggregated level provides solid insights where possible clusters are located. However, although the CI provides useful results, it is – like all other quantitative measuring methods – just a first step in identifying cluster structures in a region. Due to other aspects – that geographical proximity of firms does not imply that enterprises cooperate [26] and intersectoral relations cannot be identified through quantitative measures – it is important to realize further studies. Functional relations can be analyzed in additional qualitative studies, through methods of network analysis or – in case of intersectoral relations – by comparing quantitative results of several related subcategories.

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